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(71) Applicant (*for all designated States except CA, US*): SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V. [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL).

(71) Applicant (*for CA only*): SHELL CANADA LIMITED [CA/CA]; 400 - 4th Avenue S.W., Calgary, Alberta T2P 2H5 (CA).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): BERKHEIMER, Earl, Eugene [US/US]; 83 West Shore Drive, Arcadia, Oklahoma 73007 (US). RUNIA, Douwe, Johannes [NL/NL]; Volmerlaan 8, NL-2288 GD Rijswijk (NL).

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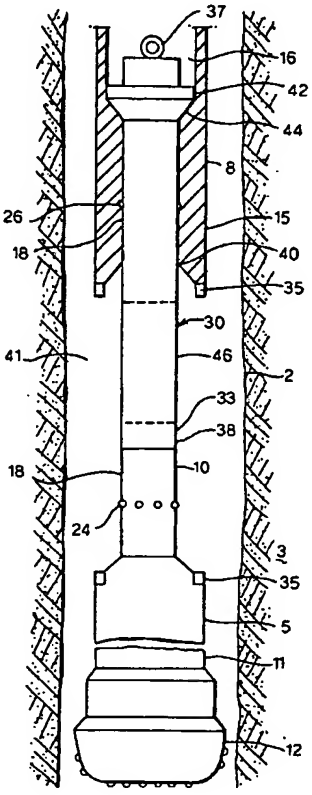
(54) Title: WELL STRING ASSEMBLY



(57) Abstract: A well string assembly (1) comprising an upper tubular well string part (8) having upper and lower ends between which there is formed a passageway; a lower well string part (5) having upper and lower ends, which lower end is spaced apart from the lower end of the upper well string part and is connectable to or includes a drill bit (12); a releasable well string interconnection means (18) for selectively interconnecting the lower and upper well string parts above the lower end of the lower well string part; and an auxiliary tool (30) arranged such that it can be passed along the passageway and comprising an operating means for manipulating the well string interconnection means so as to disconnect the lower well string part from the upper well string part, and wherein the auxiliary tool is arranged such that it can be passed, after disconnecting the upper and lower well string parts, through an opening at the lower end of the upper well string part, so as to reach a working position in which at least part of the auxiliary tool is not radially surrounded by a part of the well string.

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WELL STRING ASSEMBLY

The present invention relates to a well string assembly suitable for performing an operation in relation to a borehole and/or earth formation external of the well string in the borehole.

The expression well string is used to refer to any string or well tubular used for operations in a borehole, such a drilling, logging, fluid transportation. The well string does not necessarily need to be tubular over its entire length. The well string can in particular be a drill string.

In the course of an operation such as drilling into an earth formation, it is sometimes desired to have access to the borehole exterior of the well string. For example, performing measurements of certain properties of the surrounding earth formation is difficult if not impossible to be done from inside a drill string. Other examples in which access to the borehole is desired include obtaining a sample of the surrounding formation, injecting a fluid such as cement or lost circulation material for prevention of fluid losses, or performing a cleaning operation such as the removal of mudcake from the borehole wall e.g. by jet cleaning.

If it is known at the start of the drilling operation what operations need to be performed, it is sometimes possible to include specialised equipment in the well string, such as a dedicated Measurement-While-Drilling (MWD) tool. Such specialised equipment is expensive, and often the need for specialised equipment is only encountered in the course of the drilling operation. In such cases the drill string has to be pulled up to

The drill bit of the known system can be used for drilling operation, when the closure element is connected to the bit body. When it is desired to log the formation, drilling operation is stopped, and the logging tool string with the auxiliary tool at its lower end is lowered through the well string into the passageway. The secondary latching device is connected to the closure element, and, simultaneously, the primary latching device is operated so as to release the closure element from the bit body. Then, the logging tool can be lowered into the wellbore ahead of the well drilling bit from where logging can be performed. After logging has been completed, the logging tool string can be pulled back into the well string, so that the closure element is re-connected to the bit body and the auxiliary tool is simultaneously disconnected from the closure element.

Although the known system allows access to the open borehole ahead of the drill bit in the course of a drilling operation with a logging tool, it has the disadvantage that a special drill bit provided with passageway and removable closure element is required.

It is an object of the present invention to provide a well string assembly which is suitable for performing an operation in relation to the borehole and/or earth formation external of the well string, wherein no special drill bit is required.

To this end the present invention provides a well string assembly comprising:

- an upper tubular well string part having upper and lower ends between which there is formed a passageway;
- a lower well string part having upper and lower ends, which lower end is spaced apart from the lower end of the upper well string part and which lower end is connectable to or includes a drill bit;

lower end of the lower well string part, or via a further length of well string including, e.g., ordinary drill pipe or elements of a bottom hole assembly.

Suitably, the auxiliary tool further comprises a lower well string connection means for connecting the auxiliary tool to the lower well string part, simultaneously with or before disconnecting the well string interconnection means. In this way it can be arranged that the lower well string part is not lost in the borehole after disconnecting.

If the auxiliary tool comprises a hang-off device co-operating with the lower end of the upper well string part, the auxiliary tool itself, suitably with the lower well string part connected to its lower end, cannot be lost in the hole.

Preferably, the well string assembly is arranged such that the lower well string part can be re-connected to the upper well string part, suitably by pulling the auxiliary tool upwardly again after the operation in the borehole has been performed.

In a preferred embodiment the upper and lower parts of the well string can be telescopically opened and closed with the auxiliary tool as central part.

The operation in relation to the borehole or formation surrounding the auxiliary tool can be performed by a further specialised tool operating through the auxiliary tool in its working position, to which end the auxiliary tool can be provided with a suitable opening. A further specialised tool can e.g. be a logging tool, an inspection tool, a sampling tool, a fluid injection tool, a cleaning tool, a placement tool for placing of equipment into the borehole, such as a packer. The further specialised tool can e.g. be lowered from surface into the auxiliary tool in its working position. The auxiliary tool itself can also be integrated with the

Figure 9 shows schematically the interaction between auxiliary tool and well string in a third situation.

When like reference numerals are used in the various Figures they refer to substantially similar parts.

Reference is made to Figure 1, showing schematically a well string assembly 1 according to the invention when arranged in a borehole 2 penetrating a subsurface formation 3. In Figure 1 the lower well string part 5 is shown connected to the upper well string part 8. The lower well string part 5 has an upper end 10 and a lower end 11, and at the lower end in this case a conventional drill bit 12 is attached. The lower well string part 5 can also include a length of conventional drill pipe as well as other elements of a bottom hole assembly such as a drill collar, directional steering devices, mud motor, measurement-while-drilling system (not shown). The lower well string part does not need to have a large diameter longitudinal passageway, but it can of course have such a passageway over a certain length.

The upper well string part 8 has a lower end 15 above, i.e. spaced apart from, the lower end of the lower well string part, when the upper and lower well string parts are connected to each other during normal operation as shown in Figure 1. The upper well string part extends to surface so that its upper end is not shown in the Figure. The upper well string part 8 is tubular, so that a longitudinal passageway 16 is formed between its upper and lower ends.

The upper and lower well string parts are releasably interconnected by a well string interconnection means 18, which is formed by a latch mechanism of co-operating parts at the upper end 10 of the lower well string part 5 and the lower end 15 of the upper well string part 8. The latch mechanism is only schematically indicated in Figure 1 by locking balls 24 on the lower well string

drill string connection means is discussed with reference to Figures 3-9.

Figure 2 shows the well string assembly 1 in a situation wherein the auxiliary tool 30 has been passed on through the opening 40 at the lower end of the upper well string part 8, to reach a working position as shown, wherein the auxiliary tool extends into a region 41 of the borehole 2 external of the well string, where part of the auxiliary tool is not radially or laterally surrounded by any of the well string parts. Neither the upper or the lower well string part surrounds this part of the tool from all radial directions. I.e. the auxiliary tool is not annularly enclosed in this working position, such that there is free access to at least part of the borehole and borehole wall. It shall be clear that the borehole wall can be formed by e.g. casing.

To fix the auxiliary tool in the working position, the auxiliary tool is provided with a hang-off device in form of a landing ring 42 at its upper end, which landing ring co-operates with a landing shoulder 44 in the upper well string part 8.

The auxiliary tool 30 further comprises a logging tool 46 on the part that is not surrounded by the well string 1 when the well string has been opened up and the auxiliary tool is in the working position as shown. It shall be clear, that instead of a logging tool 46 also another means for performing an operation in relation to the borehole or formation surrounding the auxiliary tool can be arranged, for example as a module that can be arranged instead of the logging tool module. Alternatively, the part indicated with reference numeral 46 only provides an opening or window (not shown) through which a further specialised tool can operate, which further specialised tool is lowered into the auxiliary tool.

can be arranged. As an alternative for locking balls, locking dogs can be used.

In the interconnected position as shown in Figure 3 the locking balls 135 are pushed radially outwardly by the inner sleeve 125, and register with the annular recess 136 arranged in the section 112 internally around the bore 120. In this way the latching device 110 and therefore the lower well string part 5 is locked to the upper well string part 8.

The inner sleeve 125 is further provided with an annular recess 137, which is, in the interconnecting position, longitudinally displaced with respect to the recess 136 in upward direction. There can also be provided inner recesses 138. As will be explained in more detail below, the interconnecting means can be operated by inducing a longitudinal motion of the inner sleeve 125 with respect to the outer sleeve 123, because in this way the locking balls 135 can be locked into and released from the groove 136.

The upper end 123a of the outer sleeve 123 is funnel-shaped so as to guide the auxiliary tool into the latching section 110, which auxiliary tool serves to connect to the lower well string part and to operate the well string interconnection means. Latching recesses 139 are arranged in the outer sleeve 123, so as to co-operate with the lower well string connection means 38 on the auxiliary tool 30 (see below).

The section 112 further comprises a two-way orienting device 140 and a spring-biased activation button 145, which are both arranged to co-operate with the auxiliary tool which can be deployed through the passageway 16 for manipulating the interconnection means 18. The orienting device 140 comprises a guiding groove 141 formed by inwardly extending rims 142a, 142b, which extend in upper and lower direction fully around the circumference of the

petals 163, which are arranged to co-operate with the latching recesses 139 in the latching device 110 of the lower well string part 5, so as to selectively and releasably connect the auxiliary tool to the lower well string part.

The inner piston 156 is provided with an operating means 33 at its lower end, in the form of a plunger 164. The plunger 164 has a cross-shaped cross-section at its lowermost end, as is best visible in Figure 6, and serves to longitudinally shift the inner sleeve 125 with respect to the outer sleeve 123 of the latching section. To this end the inner piston 156 is longitudinally movable with respect to the outer member 155. The plunger 164 is shown at 166 in a first, retracted position. This position at the same time characterizes the relative position between the first, outer member 156 and the inner piston (second member) 156. This is also visible from the upper part of the auxiliary tool 30 in Figure 4, wherein the shaft 167 that is connected to the upper part of the inner piston 156 is fully retracted from the upper part of the outer member 155. The shaft 167 has a shoulder 168, and is connected via a swivel 169 to other equipment (not shown) forming part of or being connected to the upper end of the auxiliary tool 30. The swivel allows free rotation of such other equipment.

With the plunger in this retracted position, the latching petals 163 of the outer member 155 have transverse flexibility towards the axis 170 of the auxiliary tool, so that they can enter into the latching section 110 and connect into the latching recesses 139. The inner piston 156 can also be longitudinally moved to assume other positions relative to the outer member 155. One such position is indicated dashed at 171, and in this position the petals 163 cannot flex anymore towards the axis.

below the plunger 164, which fingers can co-operate with recesses 138 in the latching device 110. In this way, also the inner piston can be connected to the lower well string part in a predetermined position, which can further contribute to fail-safe operation in the event of strong longitudinally outward (downward) forces on the lower well string part 5 due to pulling or pumping.

The function of the parts to ensure fail-safe operation will become clear from the discussion of Figures 7-9.

Figures 7-9 show several stages of the interaction between the auxiliary tool 30 and the interconnection means 18 when the interconnection means is operated so as to disconnect the upper and lower well string parts. Reference numerals correspond to those already used in connection with Figures 1-6.

The well string 1 with the upper and lower well string parts interconnected as shown in Figure 1 can be used for progressing the wellbore 2.

When it is desired to perform an operation in the open borehole 2, the drill bit 12 is first positioned a distance above the bottom of the borehole. Then, the lower well string part 5 can be disconnected and lowered to create space for operation between the upper and lower well string parts.

For disconnecting, the auxiliary tool 30 is lowered from surface or from a position inside the upper well string part 8 along the passageway 16 to reach the section 112.

When lowering the auxiliary tool 30, the inner piston 156 is in its retracted position 166, which is also referred to as the first position relative to the outer member 156 in the specification and in the claims. When the lower part of the auxiliary tool enters the section 112, the key 190 engages the upper camming

allowed to move inwardly, thereby unlocking the lower well string part 5 from annular recess 136, i.e. from the upper well string part 8. In this way the plunger 164 forms an operating means for the interconnection means 18. The relative position between the inner piston 156 and the outer member 155 at which the locking balls are fully released from the annular recess 136 is referred to as the second relative position in the specification and in the claims.

In the position shown in Figure 8, the inner piston 156 prevents inward flexing of the petals 163, so that the auxiliary tool 30 is securely locked to the lower well string part 5. Also, in this position the recess 175 on the inner piston has moved so far that it registers with the lower trigger 173 (second retainer device). The lower end of the lower trigger 173 is forced into the recess 175 by the action of the spring 187, and blocks the longitudinal upward motion of the inner piston 156 with respect to the outer member 56 when the closure element 10 is unlatched.

By further pushing on the auxiliary tool 30 in lower direction the lower well string part 5 is pushed away from the upper well string part. Part of the auxiliary tool reaches the open borehole and is not radially surrounded by the well string, so that an operation can be performed as discussed with reference to Figure 2. Suitably the auxiliary tool can be hung off in the bottom hole assembly as shown in Figure 2.

The well drilling bit 1 and auxiliary tool 30 are such designed that the lower well string part 5 can be re-latched to the upper well string part 8 if that is desired after the operation in the open borehole has been performed.

To this end the auxiliary tool is pulled in upward direction again. The lower trigger 173 interacting with

inward flexing motion of the petals 163. Therefore, by further pulling the auxiliary tool up, e.g. from surface, the petals 193 disengage from the recesses 139, and to this end the upper edges are slightly bevelled as shown in the drawing. After pulling slightly further, the button 145 disengages from the upper trigger 172 which will subsequently prevent the inner piston from moving in downward direction again.

As shall be clear from the foregoing discussion, the embodiment of the auxiliary tool and well string discussed with reference to Figures 3-9 allows fail-safe opening of the well string interconnection means and the lower well string connection means, by simply passing/pushing the auxiliary tool down the upper well string part (e.g. by using tubing extending to surface or pumping). In particular it prevents that the lower part of the well string can be lost in the well bore. Also, fail-safe re-connecting is possible by simply passing/pulling the auxiliary tool up again (e.g. by tubing or wireline).

In this embodiment two functions of the auxiliary tool are decoupled, on the one hand the connection of the lower drill string part to the auxiliary tool, and on the other hand the operation of the well string interconnection means. Decoupling is achieved in a specific way, so that the interconnection means can only be operated when the auxiliary tool is connected to the lower drill string part. In this way it is prevented that the lower drill string part can be lost in the wellbore, since it can only be disconnected from the upper well string part if it is fully connected to the auxiliary tool.

Decoupling of these functions is achieved in that the auxiliary tool comprises first and second members, each of which is associated with mainly one of the functions,

applications Nos. 03250243.7 and 03250242.9, not published at the priority date of the present application. Both these European patent applications were abandoned before the date of filing of the present application, and have served as priority applications for the International patent application No. PCT/EP2004/050017, into which the subject-matter of both European patent applications was included.

It shall be clear that other interconnection means and auxiliary tools can also be used with the present invention, for example similar to the latching mechanism for drill bits suitable for through-bit operation, described in International patent applications publication No. WO 00/17488 and WO 03/004825, wherein the role of the upper and lower well string parts is played by the bit body and the closure element for the longitudinal passageway in the bit body, respectively.

In some applications it may not be a problem to lose the lower drill string part in the borehole after disconnecting, so that the lower drill string connection means is not needed.

The present invention can be used to arrange that a well string can be opened up at any desired position location above its lower end. It is only required to arrange a suitable interconnection means at that position. The interconnection means does not interfere with the normal drilling operation but provides flexibility to perform an operation in the borehole. When a well string assembly is deployed in a borehole, the invention can be used to perform an operation in the borehole exterior of the well string, which can be an open borehole, or also a partly or fully completed wellbore.

The lower well string part can include all or part of the so-called bottom hole assembly of a well string.

C L A I M S

1. A well string assembly comprising:
- an upper tubular well string part having upper and lower ends between which there is formed a passageway;
- a lower well string part having upper and lower ends, which lower end is spaced apart from the lower end of the upper well string part and which lower end is connectable to or includes a drill bit;
- a releasable well string interconnection means for selectively interconnecting the lower and upper well string parts above the lower end of the lower well string part; and
- an auxiliary tool arranged such that it can be passed along the passageway of the upper well string part, wherein the auxiliary tool comprises an operating means for manipulating the well string interconnection means so as to disconnect the lower well string part from the upper well string part, and wherein the auxiliary tool is arranged such that it can be passed, after disconnecting the upper and lower well string parts, through an opening at the lower end of the upper well string part, so as to reach a working position in which at least part of the auxiliary tool is not radially surrounded by a part of the well string.

2. The well string assembly according to claim 1, wherein the auxiliary tool further comprises a lower well string connection means for connecting the auxiliary tool to the lower well string part simultaneously with or before disconnecting the well string interconnection means.

3. The well string assembly according to claim 1 or 2, wherein the auxiliary tool comprises a hang-off device

longitudinally slideably along the passageway with respect to the first member, so that the first relative position is an upper position of the second member, and wherein the second member is moved relative to the first member in downward direction when moving it towards the second relative position.

9. The well string assembly according to claim 8, wherein the first member of the auxiliary tool comprises a substantially tubular body in which the second member is coaxially slideably arranged, wherein the lower well string part comprises at its upper end an outer sleeve and a coaxial inner sleeve, wherein the upper end of the outer sleeve is arranged to cooperate with the lower well string connection means so as to lock the auxiliary tool to the outer sleeve, wherein the upper end of the inner sleeve is arranged to cooperate with the operating means of the auxiliary tool so that the interconnecting means is operated by longitudinally sliding the inner sleeve with respect to the outer sleeve.

10. The well string assembly according to any one of claims 1-9, wherein interconnection means, auxiliary tool and optionally lower well string connection means are arranged such that the lower and upper well string part can be reconnected again after disconnecting.

11. Use of a well string assembly according to any one of claims 1-10 for performing an operation in a borehole, external of the well string.

Fig.2.

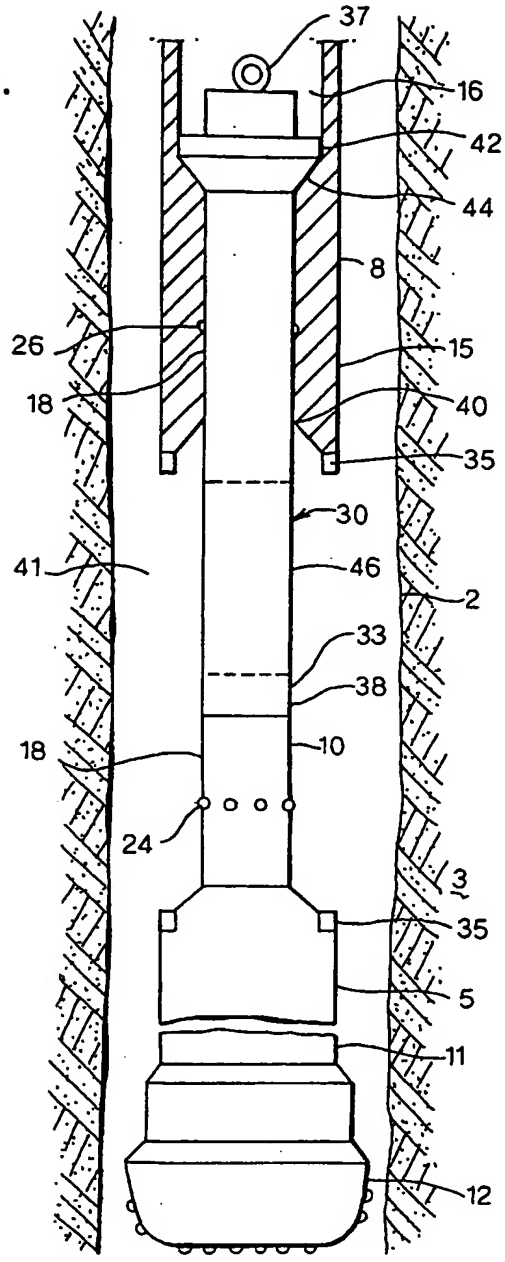


Fig.4.

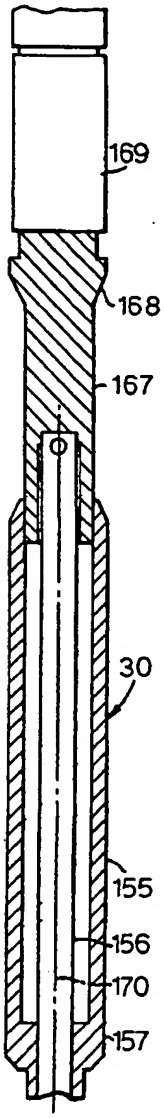


Fig.6.

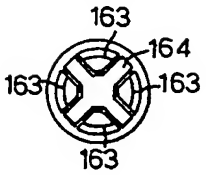


Fig.5.

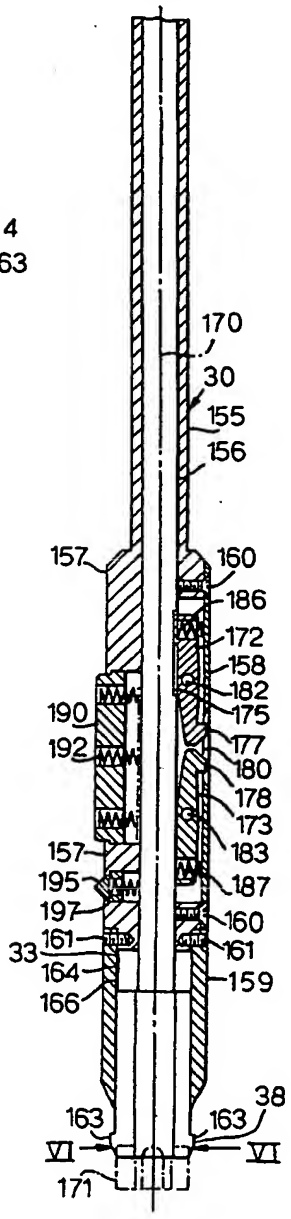
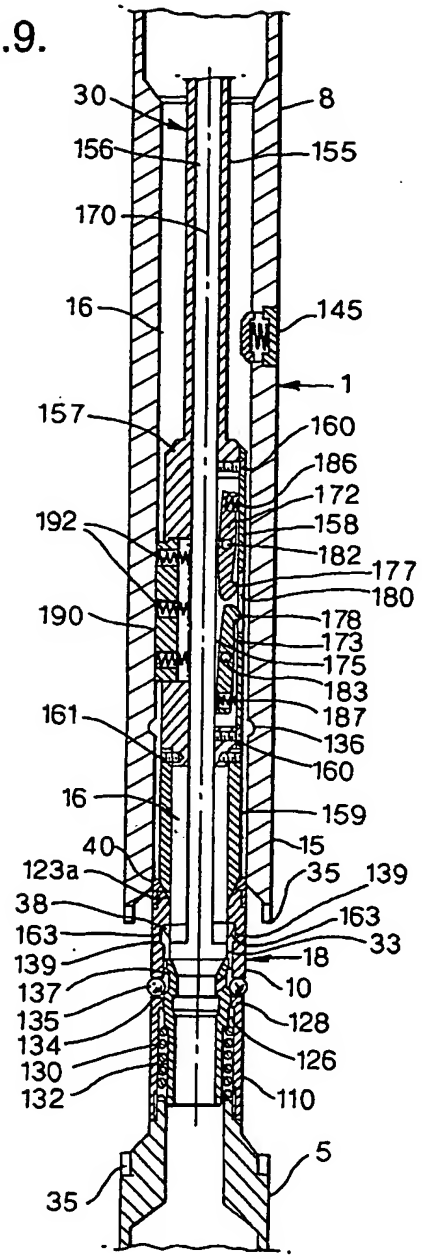


Fig.9.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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP2004/050542

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